

9 p.

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N64-15967

① Progress Report for November 1962

EVALUATION OF REGENERATIVE FUEL CELL

CODE-1

(NASA) CR-53067;

Prepared for

National Aeronautics and Space Administration  
Western Operations Office  
150 Pico Boulevard  
Santa Monica, California

(NASA

Contract NAS7-181)

EOS Report 3310-ML-4)

10 December 1962

9p (conf)

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17075

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OTS:PRICE

XEROX

\$ 1.10 ph

MICROFILM

\$ 0.80 mf

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## 1. INTRODUCTION

15967 *Author*  
The electrode studies have been completed except for temperature dependance, and perhaps some additional work with silver oxide electrodes. Further studies on the effect of foreign ions have substantiated our earlier conclusions for the hydrogen electrode, but not for the oxygen electrode. It now appears that other factors are more important for the latter electrode.

Radioactive doped sintered silver electrodes were studied in a hydrogen-oxygen cell at room temperature and 70°C. It is concluded that they do not look promising.

Hydrogen storage in a sintered palladium electrode was studied at several, rather high current densities. It was found that little or no pressure build-up occurs, indicating that the hydrogen is absorbed as fast as it is formed, even at very high charging rates. This fact, coupled with favorable discharge characteristics, indicates that the system  $\text{Ag}_2\text{O-Pd(H}_2\text{)}$  may become competitive with several existing rechargeable systems. *Author*

## 2. ELECTRODE STUDIES

Most of the electrode studies are now complete. During November, work was finished on the effect of foreign ions ( $\text{Ba}^{++}$  and  $\text{CO}_3^{=}$ ). The conclusions reached last month regarding this effect are modified in some respects.

The conclusions reported earlier for the hydrogen electrode have been largely substantiated, but those for the oxygen electrode have not. It appears that factors other than the electrolyte purity may be more important in determining oxygen electrode performance.

### 2.1 Radioactive Electrodes

Four sintered silver electrodes, containing a silver screen for strength, were made up for evaluating radioactive electrodes for possible use in fuel cells. Three were sent to Yardney Electric Company where two of them were doped with  $\text{Po}^{210}$ , an  $\alpha$  emitter. The third one was doped with  $\text{Pm}^{147}$ , a  $\beta$  emitter. The fourth electrode was saved for a control. All four were tested as oxygen electrodes in a hydrogen-oxygen cell at room temperature and at  $70^\circ\text{C}$ . No correlation between radioactivity and electrode polarization was demonstrated. In addition to this result, it was demonstrated that our present platinum blacked nickel electrodes are better at room temperature than any of the silver electrodes are, radioactive or otherwise, at either room temperature or  $70^\circ\text{C}$ . Therefore, no further work is anticipated with these electrodes.

### 2.2 Silver Oxide Electrodes

Further work was accomplished with silver oxide electrodes during November. Silver electrodes were made with doped and undoped silver oxide, where the doping agent was cobalt. Both doped and undoped electrodes were made and washed with the electrolyte in two cases and with distilled water in two cases. Thus, there were four electrodes studied: 1) doped and washed with electrolyte, 2) doped and washed

with water, 3) undoped and washed with electrolyte and, 4) undoped and washed with water. For each experiment the cells were discharged completely through a 1 ohm resistor and charged until the second silver plateau was reached. The silver electrodes were later analyzed, using the Volhard method, to determine the total amount of silver present.

The evidence appears good at this time that the cobalt doped silver oxide is superior to the undoped material, especially at higher current densities. However, the effect is small. At  $64 \text{ ma/cm}^2$  the extreme spread for the four electrodes was approximately from 50 to 60 percent of theoretical for the first silver plateau.

### 2.3 Hydrogen Storage in Palladium

A hydrogen electrode was fabricated by sintering palladium powder onto a fine platinum screen. A palladium catalyst was applied by thermally decomposing  $\text{Pd Cl}_2$  at  $500^\circ\text{C}$  on the sintered palladium electrode. About  $7.5 \text{ mg Pd/cm}^2$  was applied in this manner. Pressure was monitored continuously while a hydrogen-silver oxide cell was charged along the first silver plateau, using the sintered palladium for the hydrogen electrode. The object was to determine polarization characteristics and the rate of pressure build-up within the cell.

The results were generally very satisfactory. Charging curves were run at 40, 80, 124, and  $155 \text{ ma/cm}^2$ . There was a very slight pressure decrease with time at  $40 \text{ ma/cm}^2$ , and although there was a very slight increase with time for the three highest charging rates, the gage pressure was always negative except for the  $155 \text{ ma/cm}^2$  rate. At the end of the latter charge, there was a positive gage pressure of about 3 psi. The reason for the negative pressures is that the hydrogen side of the cell was swept with hydrogen, in the usual manner, before each run and this was then quickly absorbed by the palladium.

The cells were discharged at the same rates at which they had previously been charged. The amp-hour ratio at  $40 \text{ ma/cm}^2$  was 95 percent; at 80 it was 87 percent; at 124 it was 75 percent; and at  $155 \text{ ma/cm}^2$  the ratio was 67 percent. The number of ma-hrs obtained on discharge was 180, 226, 258, and 104 respectively. The weight of palladium

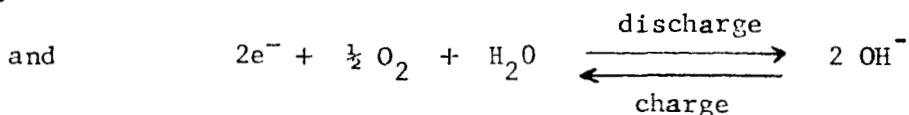
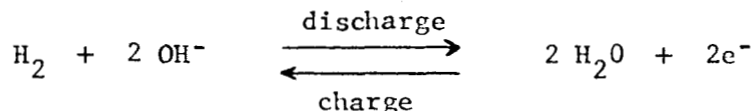
(minus the platinum screen) was 1.399 gm. However, it was not shown that these figures represented the capacity of the palladium or the capacity of the silver.

Polarization characteristics were about normal for a hydrogen electrode catalyzed with pure palladium. No reliable results were obtained for individual electrodes as the hydrogen reference electrode failed repeatedly, probably because it was a platinum catalyzed, sintered nickel electrode and a hydrogen gas pressure could not be maintained on it in the presence of the sintered palladium electrode. Some additional work is planned for this system in which a palladium hydrogen reference electrode will be used. A mixed platinum-palladium catalyst will be studied for the working electrode.

### 3. ELECTROLYTE STORAGE EXPERIMENTS

A new cell has been designed and constructed for capacity experiments. An analysis of the energy storage/weight capabilities of the hydrogen-oxygen system quickly reveals that this ratio will be limited more by the amount of stored electrolyte than by the weight of the gas storage cylinders. In all cells studied to date in this laboratory, the only electrolyte storage has been between the electrodes. The new cell, shown in Figure 1, is designed to allow electrolyte storage behind the electrodes. The gas for each electrode is brought up through a hole in the electrolyte storage bed to a screen immediately behind the electrode. The gas port sleeves serve a triple function. They allow gas passage up to the nickel screen, where the gas is then dispersed across the entire back of the electrode, they make electrical contact to the electrode, and they determine the spacing (at least at two points) between the electrodes.

The storage behind the hydrogen electrode was made twice as much as that behind the oxygen electrode because a consideration of the individual electrode reactions shows that twice as much water is consumed or produced (for the charge or discharge process, respectively) at the hydrogen electrode as at the oxygen electrode. These electrode reactions are



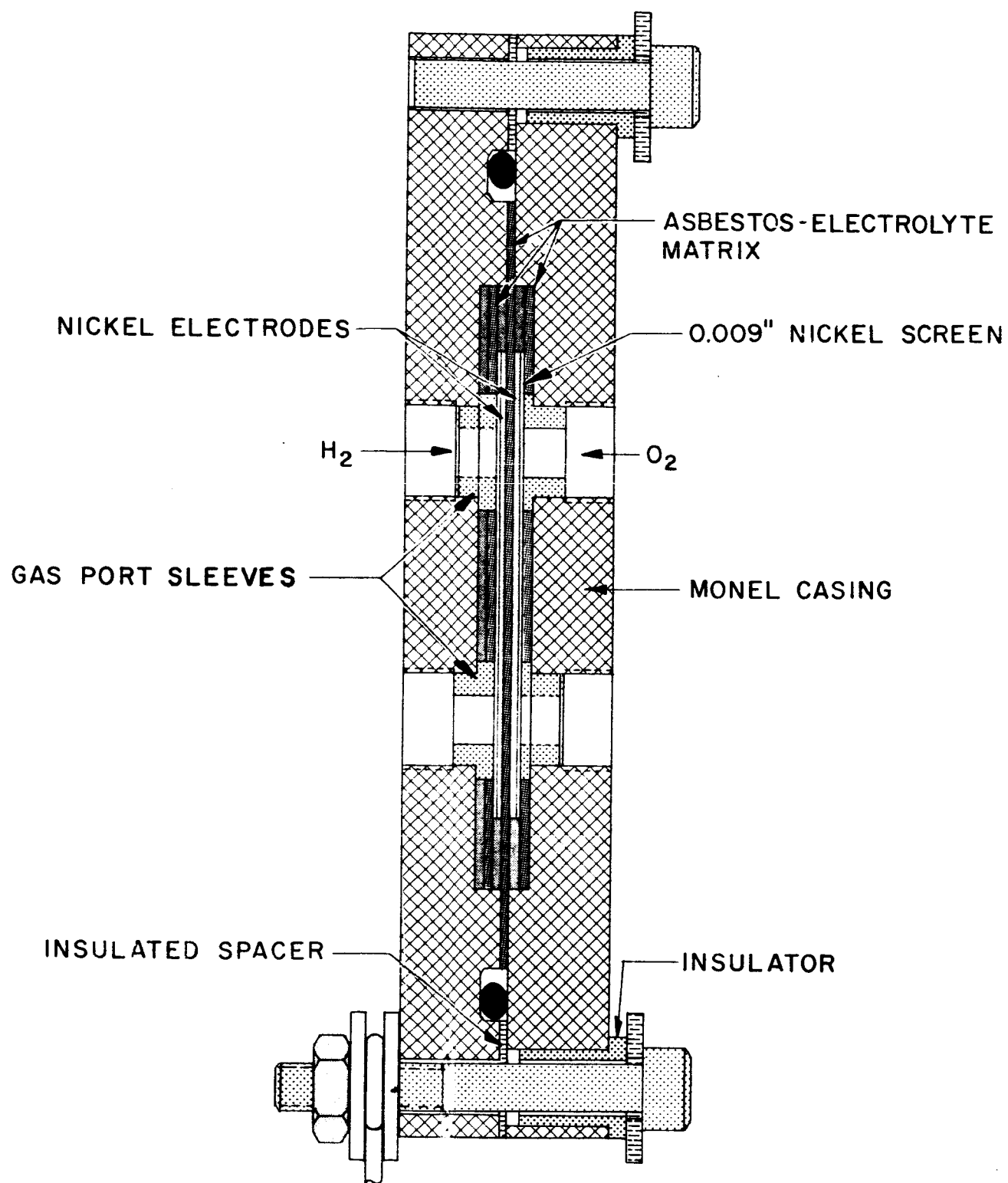


FIG. 1 HYDROGEN-OXYGEN FUEL CELL FOR ELECTROLYTE STORAGE EXPERIMENTS



#### 4. FUTURE PLANS

Certain phases of the electrode development, such as the effect of temperature on electrode performance, remain to be done. These will be finished in December. A small amount of additional work may be done also to help clear up the effect of doping on silver oxide electrodes.

It is expected, however, that most of the month will be devoted to capacity tests on the new cell. Since most of the electrolyte is stored behind the electrodes, it is possible that the charging and/or discharging rates will be limited. This is because the electrolyte will have to flow to and from the region behind the electrodes as it is made and consumed, respectively. For this reason, capacity will be determined as a function of current density.

#### 5. ADMINISTRATIVE REPORT

For November 1962 a total of 472 labor hours were expended.

Dollar commitments: \$40.